IS 9001-16 (1985): Guidance for environmental testing, Part 16: Acoustic noise test [LITD 1: Environmental Testing Procedure]

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART 16 ACOUSTIC NOISE TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART 16 ACOUSTIC NOISE TEST

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GUIDANCE FOR ENVIRONMENTAL TESTING

PART 16 ACOUSTIC NOISE TEST

0. FOREWORD

0.1 This Indian Standard (Part 16) was adopted by the Indian Standards Institution on 25 July 1985, after the draft finalized by the Environmental Testing Procedures Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard (Part 16) covers the guidance details for acoustic noise test. The test procedure is covered in IS : 9000 (Part 21)-1985*.

0.3 While preparing this standard, considerable assistance is derived from Test No. 2 of JSS 55555-1977 'Environmental test methods for electronic and electrical equipment', issued by the Ministry of Defence, India.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 16) covers guidance details for acoustic noise test for electronic and electrical items.

2. CHOICE OF TEST SPECTRA

2.1 The test spectrum given in Fig. 2 of IS : 9000 (Part 21)-1985* is derived from consideration of the following factors.

*Basic environmental testing procedures for electronic and electrical items: Part 21 Acoustic noise test.

†Rules for rounding off numerical values (*revised*).

2.1.1 The external exhaust overall noise level can range from 130 to 165 dB when both jet and rocket noise are considered. Below this range acoustic problems are unlikely, whilst above this range special attention is necessary.

2.1.2 The maximum band level occurs in the frequency range 200 to 1 000 Hz with a 6 dB per octave roll off at higher and lower frequencies.

2.1.3 The attenuation by the skin, etc, below 1 000 Hz is of the order of 10 dB. Above 1 000 Hz the attenuation can increase at a rate of 6 dB per octave, giving up to 30 dB attenuation at higher frequencies. However, these figures are only generalizations since many factors may be involved.

2.1.4 Depending on the type of vehicle, maximum boundary layer noise will normally be in the region of 145 dB, with a spectrum closer to white than that for jet noise.

2.1.5 When exhaust and boundary layer spectra are combined, and skin attenuation is taken into account, the result is similar to the external spectrum for jet noise only.

2.1.6 Although the preferred signal should be random, reverberation conditions may modify the amplitude distribution giving misleading distribution measurements in the reverberation chamber.

2.1.7 These considerations give rise to general purpose test, but should one particular type of noise predominate, a special test may be required.

3. SOME CONSIDERATIONS IN THE SELECTION OF A TEST FACILITY

3.1 Choice of Test Chamber — The test is based on conditions arising primarily with aircraft equipment which operate in an enclosed compartment. Hence the first characteristic of the normal environment is that of an enclosed space.

3.1.1 The greater part of the acoustic field in such enclosed compartments is usually due to secondary radiation of sound from vibration of the surrounding structure. Thus the sound radiating source may comprise a large area of the compartment.

3.1.2 A combination of enclosed space, reflective surfaces and a relatively large radiating area, will result in sound waves being reflected and transmitted in random directions to build up a diffuse field. This is closely simulated in a reverberation chamber. Other types of chamber that may be considered would not give the same correlation of pressures over the item, and would therefore not excite item resonances in quite the same way.

3.2 Realism in the Choice of Test Chamber Size — The class of equipment and components to be dealt with is to be confinedto the airborne type, although some conclusions may have more general applications.

3.2.1 Much airborne equipment will be in the form of 'black boxes', which will generally be the largest items to be tested. They will seldom approach 1 m^3 in volume, a more realistic limit being in the order of 0·1 m^3. In general, components will be enclosed inside the black boxes so that, for the component, the environment is enclosed in the box (or whatever equipment the component operates in).

3.2.2 The volume of operating space for equipment cannot be specified, although some generalizations may be permissible. The largest volumes are usually passenger and crew compartments where an overall noise level of less than 120 dB makes noise problems unlikely. Crew compartments of small military aircraft have a relatively small volume (8 m^3 or less), but noise levels up to 135 dB are possible. Generally, airborne equipment subject to intense noise environments will be operating in small compartments in the nose, tail wings and underfloor compartments. Possible exceptions are where aircraft have large underfloor cargo spaces, or in the case of military aircraft where electronic equipment may be carried in large bomb bays.

3.2.3 It is unlikely to find equipment operating in volumes of the order of 500 m^3, and even more unlikely that such equipment will require an acoustic test. Components will operate in an environment formed by the casing of the equipment and can therefore be tested in a small test chamber.

3.3 Standardization of Test Conditions — Standardization of test conditions is needed if different establishments are to obtain similar results with the same type of item. In addition, if the cataloguing of equipment as complying with a specification is to have meaning, the conditions need to be related to some standard conditions. These conditions would include frequency spectra, sound pressure levels and type or pattern of acoustic field.

3.4 Preferred Test Chambers — The best available means of achieving a representative test is to obtain standardization by testing in standard forms of chamber, and to obtain realism by having these forms of realistic size. A range of three test chamber sizes has been chosen to cover most likely cases:

a) A small test chamber suitable for component testing;

b) A medium sized chamber to cater for a wide range of equipment; and

c) A large chamber to provide for cases needing larger volume.

3.4.1 The size and shape of the chambers have been chosen to meet an effective compromise between technical and economic considerations.

3.5 Acoustic Noise Generators — For the acoustic test, a source should be capable of delivering controllable random noise at high power, controllable in that the shape of the spectrum can be changed without altering the randomness of the output. A high efficiency is also desirable, although this tends to take second place to the requirement mentioned first.

3.5.1 At the present time, the most suitable devices are those which are electromagnetic in operation; loudspeakers and electromagnetic air modulators. The only other suitable device is the random siren although this is of doubtful value due to control problems. No available noise generator is entirely satisfactory from power output, spectral range, or controllability points of view.

3.5.2 More details of these generators should be obtained from current literature.

4. PREFERRED CHAMBER AND GUIDE TO SUITABLE SOURCES

4.1 Test Chambers

4.1.1 The preferred test chamber is an uneven pentagon as shown in Fig. 1 of IS : 9000 (Part 21)-1985* and in order that a measure of standardization of the test can be achieved it is recommended that the size of the chamber be chosen from one of three sizes having the following dimensional constants:

$n = 0{\cdot}5$ m

$n = 1{\cdot}25$ m

$n = 3$ m

The mean absorption coefficient ($\overline{\alpha}$) should be between 0·03 and 0·04.

4.1.2 Material suitable for the test chamber include painted brickwork, smoothed concrete, or steel or aluminium plate. Vibration damping of the wall and horns coupling the sources to the chamber is of importance if high absorption, due to mechanical resonance, is to be avoided. Absorption coefficients for these materials commonly range from 0·02 to 0·05; with adequate vibration damping the figure is closer to 0·02 than 0·05.

*Basic environmental testing procedures for electronic and electrical items: Part 21 Acoustic noise test.

4.1.3 Brick and concrete may also give figures of less than 0·02, although this should normally be avoided. The recommended range for $\bar{\alpha}$ is a compromise between power requirements, diffusion and smoothness of frequency response. Absorption coefficients, when tending to be high, may sometimes be reduced by coating the appropriate surfaces with an epoxy paint.

4.1.4 The sound source opening and the item are also absorbers of acoustic energy. Initially it may be found best to assume the absorption coefficient of the sound source opening to be unity ($\bar{\alpha} = 1$).

4.1.5 Absorption by the item would normally be 10 W, as the item would have a similar absorption coefficient range to those materials quoted above. If, however, the item to be tested has non-metallic or highly resonant surfaces, special consideration should be given to the absorption by the item.

4.2 Acoustic Power Requirements — The basic power requirement may be initially estimated from:

$$\text{Power Watt Level } (PWL) = SPL - 10 \log_{10}\left(\frac{4}{R}\right) \text{dB referred to } 10^{-12} \text{ watt}$$

where

PWL = $10 \log_{10} W + 120$ dB;

W = acoustic power in watts;

SPL = sound pressure level in decibels referred to 2×10^{-5} Pa; and

R = room constant in m^2 is found from:

$$R = \frac{S\bar{\alpha}}{1 - \bar{\alpha}}$$

S = total surface area absorbing acoustic energy in m^2; and

$\bar{\alpha}$ = mean absorption coefficient of the surface area.

4.2.1 Most sound sources deliver their power unevenly through the spectrum, so that spectrum shaping may be accomplished by reducing the power output in the most efficient part of the output spectrum of the source. Additional power may, therefore, be required to allow for the inefficiency of the source in parts of its output spectrum.

4.2.2 For the test chambers recommended in **4.1.1** the higher absortion coefficient ($\bar{\alpha} = 0.04$) should be assumed in initial calculations.

4.3 Source Requirements — An indication of power requirements and of the type of source which may be associated with the recommended test chamber, is given in Table 1.

TABLE 1 TYPICAL SOURCE REQUIREMENTS

(*Clause* 4.3)

Spectrum Approx Overall SPL		Grade A 130 dB	Grade B 140 dB	Grade C 150 dB	Grade D 160 dB
Test chamber $n = 0.5$ m*	Acoustic power	0·5 W (A)	5 W (A)	50 W (A)	500 W (A)
	Source	30 W (E) loudspeaker	100 W (E) pressure drive unit	6 off 100 W (E) pressure drive unit or 50 W (A) air modulator	500 W (A) air modulator
Test chamber $n = 1.25$ m*	Acoustic power	5 W (A)	50 W (A)	500 W (A)	4 kW (A)
	Source	100 W (E) pressure drive unit	6 off 100 W (E) pressure drive unit or 50 W (A) air modulator	500 W (A) air modulator	2 off 2 kW (A) air modulator or random siren
Test chamber $n = 3$ m*	Acoustic power	25 W (A)	250 W (A)	2 kW (A)	16 kW (A)
	Source	3 off 100 W (E) pressure drive unit or 25 W (A) air modulator	250 W (A) air modulator	2 kW (A) air modulator	8 off 2 kW (A) air modulator or random siren

**See* Fig. 1 of IS : 9000 (Part 21)-1985 Basic environmental testing procedures for electronic and electrical items: Part 21 Acoustic noise test.

4.3.1 Acoustic powers, as calculated by the method in **4.2** have been increased to allow for spectrum shaping and other uncertainties.

4.3.2 Input power for loudspeakers and pressure drive units is given in electrical watts, all other power being given in acoustic watts. In the table these are shown as watts (*E*) and watts (*A*) respectively.

4.3.3 Any individual device may not necessarily cover the whole of the frequency range required.

4.3.4 The air modulators referred to are not necessarily commercially available in the intermediate sizes, but represent types which are feasible and would be suitable. A 2 kW (A) modulator is available and could be used in the absence of intermediate sizes.

4.3.5 The use of a large number of sources should be avoided where possible. Since the source area is absorbent to sound, the addition of extra sources will increase the absorption and a state may be reached where the SPL falls when more sources are added. Thus one high powered source is in general more effective than a number of low powered sources.

4.3.6 A random siren is a possible alternative to the air modulator where very high acoustic powers are required. With this type of device, however, spectrum shaping is very difficult to achieve. In addition, special care should be taken to ensure that the output is random under all conditions of use.

4.3.7 Unless otherwise specified in the relevant specification, the time duration to expose the item in the different types of sound pressure chambers shall be taken as 10 hours.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	k
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	$1\ N = 1\ kg.m/s^2$
Energy	joule	J	$1\ J = 1\ N.m$
Power	watt	W	$1\ W = 1\ J/s$
Flux	weber	Wb	$1\ Wb = 1\ V.s$
Flux density	tesla	T	$1\ T = 1\ Wb/m^2$
Frequency	hertz	Hz	$1\ Hz = 1\ c/s\ (s^{-1})$
Electric conductance	siemens	S	$1\ S = 1\ A/V$
Electromotive force	volt	V	$1\ V = 1\ W/A$
Pressure, stress	pascal	Pa	$1\ Pa = 1\ N/m^2$